Report for 2004IN158B: Potential of Controlled Drainage to Reduce Nitrate Contamination at the Watershed Scale

There are no reported publications resulting from this project.

Report Follows

Title: Potential of Controlled Drainage to Reduce Nitrate Contamination at the Watershed Scale

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Problem and Research Objectives

About 50% of all cropland in Indiana is artificially drained with subsurface tile drainage systems. While artificial drainage is necessary for insuring field operations and crop production, it has environmental costs, increasing nitrate-N load to surface water. Controlled drainage has been shown, in plot- and field-scale studies, to reduce nitrate losses from subsurface-drained soils. Control structures are used to hold the water table at a higher level during the non-growing season in November to March when most of the drainage and nitrate loss occur. Controlled drainage could have an important impact on annual nitrate load in streams and rivers that drain heavily-drained watersheds. Although field and modeling studies provide estimates of potential nitrate loss reduction at the field scale, no studies exist that estimate how much nitrate reduction is possible from implementation of controlled drainage at the mid-size watershed scale. The goal of this study is to quantify the potential benefit of controlled drainage in reducing nitrate-N load to surface water in mid-sized watersheds, under the weather and soil conditions in Indiana.

Methodology and Principal Findings

Watersheds less than 1000 square miles in area, having both nitrate concentration data (minimum 48 nitrate samples since 1990) and daily stream flow were identified from USGS and Indiana Department of Environmental Management (IDEM) data. This resulted in 33 watersheds (Figure 1), for which we are delineating watershed boundaries and estimating drained area in each watershed from land use and soil drainage classes, based on the assumption that row-crop fields in poorly drained soil are very likely to have tile drainage in Indiana.

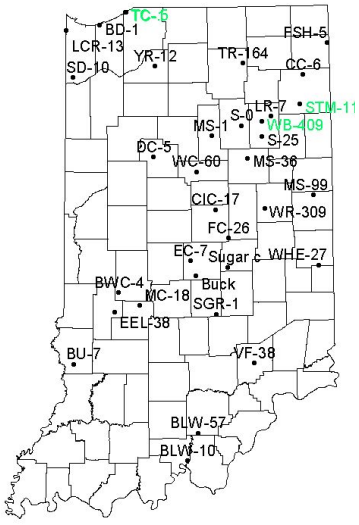

Figure 1: Streamflow gauges where sufficient nitrate-N concentration data are available.

We then calculated average monthly nitrate-N load per unit watershed area by averaging nitrate load (nitrate-N concentration multiplied by daily flow) for each month through all the years of data. In order to see the variation of nitrate load through years, monthly nitrate load for three watersheds were plotted versus time. From field measurements, we know that tile drain affects nitrate concentrations mostly from January to July, while point sources often remain more or less constant throughout the year. Three examples are presented in Figure 2. The estimated percentage of the area that is tile-drained row crops, ranging from 0% to 71%,

is shown in the legend. From January to July, average nitrate-N load per unit area is higher in more highly drained watersheds, while from August to December, nitrate-N load per unit area is not correlated to drained area.

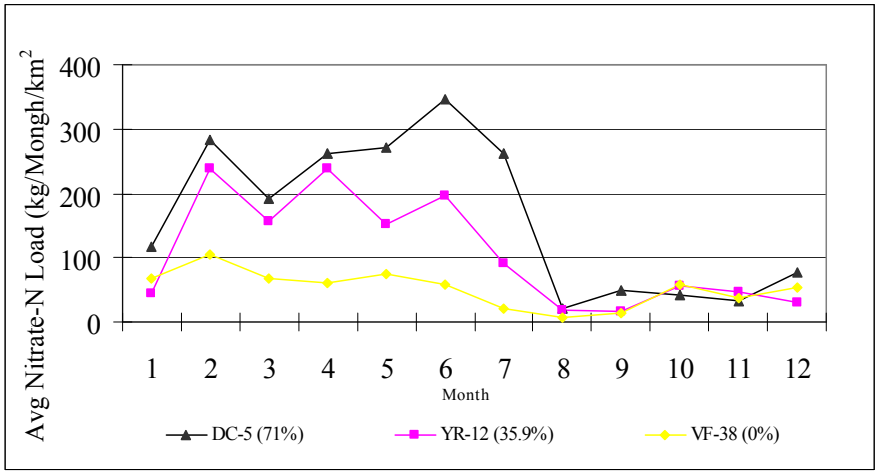

Figure 2. Long term average nitrate-N load by month (kg/Month/km^2) for 3 watersheds with high, medium, and low percentage of the watershed that we estimate to be drained agricultural land

We are currently expanding this analysis, and developing a means to estimate the total nitrate load from tile drainage for a particular watershed from statistical analyses of the temporal and spatial relationships of these nitrate-N loading patterns. A preliminary regression study on the difference of average monthly concentration over March, April and May versus Aug., Sept., and Oct. and the percentage of drained area was done for 11 watersheds.

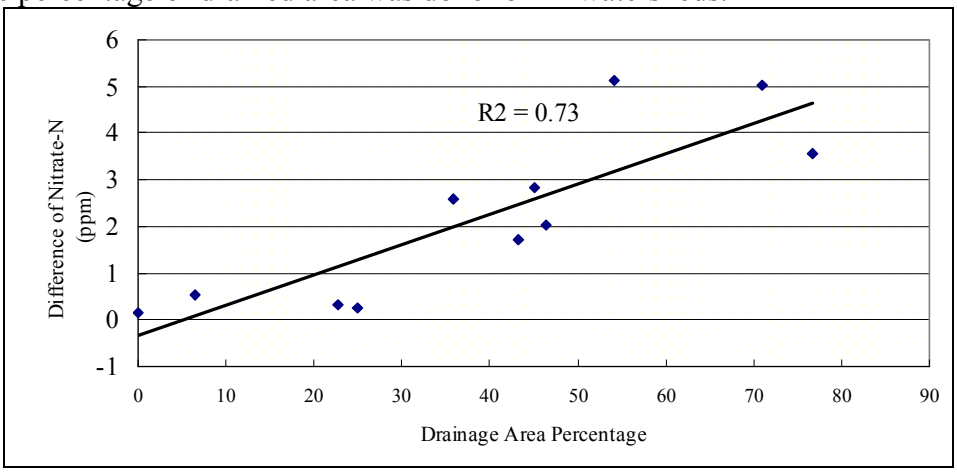

Figure 7. Linear regression of nitrate difference (average concentration in March, April, May versus Aug., Sep., and Oct.) and drained area percentage

Once we have completed the analysis of current nitrate loading from tile drains, we will then estimate potential reductions at the watershed scale from implementation of controlled drainage in areas where it is an appropriate management practice.

We have also begun work on simulating one of the most highly-monitored watersheds, Sugar Creek, with the Soil and Water Assessment Tool (SWAT) model. SWAT uses digital elevation data, land use, soils maps, daily precipitation, temperature and solar radiation for the watershed to predict the effects of different management scenarios on water quality. The new SWAT-2003 version (released in early 2005) has been modified to better simulate landscapes with tile drains, particularly to predict nitrate-N loadings.

Significance

Controlled drainage, or drainage water management, is being promoted by the drainage industry. New NRCS practice standards have made cost-share available in many watersheds. However, the impact of this practice at the watershed level remains unknown. This study will provide the first mid-size watershed estimates of potential impacts of the practice, which will aid policy makers and technical agency staff in evaluating the potential of controlled drainage to benefit local, regional, and national interests. Expected local and regional benefits of the practice include decreased nitrate loading to streams, and national benefits include reduced nitrate loading to major river systems and to the Gulf of Mexico. This study will help determine the magnitude of the benefits.

Students

Roxanne Mitchell, Ph.D. student, has carried out background study on controlled drainage. Yinghui Sui, Ph.D.student, has carried out GIS and data analyses, and SWAT modeling.

Thesis Titles, Papers, Abstracts

This work is still in progress and has not yet been presented. The information gained will be delivered to the agricultural community, the drainage industry, environmental officials, and the public.